4 Basis for Remedial Action

As described in the RI Report (Anchor QEA and Aspect 2012) and summarized in Section 3, the Site has been characterized and is well understood for the purposes of supporting remedial alternative development, evaluation, and selection. Based on the results of the RI, this FS Report evaluates technologies and develops and screens remedial alternatives for the Site. This section presents the ARARs, RAOs, and PRGs that were used in this analysis.

Section 4.1 identifies and discusses the Quendall ARARs that are mostly likely to have a significant influence on the identification and assembly of remedial alternatives to be evaluated in this FS. However, any alternative selected for the remediation of the Quendall site will have to comply with all ARARs unless an ARAR is waived by EPA. A preliminary list of ARARs for Quendall is presented in Tables 4-1 through 4-3[1]. Section 4.2 identifies the RAOs, which describe what the proposed remedy is expected to accomplish. Section 4.3 discusses the PRGs, which are the numerical concentrations that are protective of human health and the environment and comply with chemical-specific ARARs. Section 4.4 discusses Site areas and media targeted for remedial action based on the presence of DNAPL and exceedances of the PRGs in Site media. This information is used as a basis for identifying and screening technologies (presented in Section 5) and developing a range of remedial alternatives (presented in Section 6).

4.1 Applicable or Relevant and Appropriate Requirements (ARARs)

One of the two CERCLA threshold criteria requires remedial actions to achieve ARARs, which are defined as any legally applicable or relevant and appropriate standard, requirement, criterion, or limitation that has been promulgated under federal or state law. Although a cleanup action performed under formal CERCLA authorities (e.g., a Consent Decree) would be exempt from the procedural requirements of these laws, the action must nevertheless comply with their substantive requirements. Under CERCLA 121 (e), federal, state, or local permits need not be obtained for remedial actions that are conducted entirely on-site. The NCP defines "on-site" as the "*areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action*" (40 CFR 300.5). Remedial activities performed off-site would require applicable permits.

According to the NCP (40 CFR 300.5), applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance identified at a

[1] "To be considereds" (TBCs) that ensure protectiveness of the remedial action may also play a significant role in remedy selection, such as risk-based concentrations for COCs without an ARAR. These are also identified in Tables 4-1 through 4-3.

CERCLA site. A requirement may not be applicable but nevertheless could be relevant and appropriate. Relevant and appropriate requirements address problems or situations sufficiently similar to those encountered at CERCLA sites that their use is well suited to the particular site.

Washington State has promulgated environmental regulations to implement certain federal programs; in cases where the state requirement is more stringent than the federal requirement, the state requirement is the controlling ARAR. In addition, some federal, and state environmental and public health agencies may develop criteria, advisories, guidance documents, and proposed standards that are not legally enforceable but that contain useful information for implementing a cleanup remedy or selecting cleanup levels. These fall into the category of criteria "to be considered" (TBCs)[2]; TBCs are not mandatory requirements but may complement the identified ARARs (see EPA 1988c).

In general, there are three categories of ARARs (see EPA 1988c):

- Chemical-specific requirements;
- Action-specific requirements; and
- Location-specific requirements.

Some ARARs fit neatly into a single category, while others may fall into more than one category. Each of these categories is described below:

- Chemical-specific ARARs are laws and requirements that establish health- or risk-based numerical values or methodologies for developing such values (EPA 1988c). These ARARs are used to establish the acceptable concentration of a chemical that may remain in or be discharged to the environment. As such, chemical-specific ARARs are considered in identifying the PRGs. Chemical-specific ARARs are listed in Table 4-1.
- Action-specific ARARs are performance, design, or other requirements that may place controls or restrictions on a particular remedial action (EPA 1988c). Action-specific ARARs are typically technology- or activity-based requirements or limitations on actions, and these requirements may include chemical-specific standards or criteria that must be met as the result of an action. For remedial actions at the Site, these requirements are not necessarily triggered by the presence of specific contaminants in Site media, but rather by the specific actions that occur at the Site. Action-specific ARARs are listed in Table 4-2.
- Location-specific ARARs are requirements that are triggered based on the location of the remedial action to be undertaken (EPA 1988c). Location-specific ARARs may restrict or preclude certain remedial actions or may apply only to

[2] Many Federal and State environmental and public health agencies develop criteria, advisories, guidance, and proposed standards that are not legally enforceable but contain information that would be helpful in carrying out, or in determining the level of protectiveness of, selected remedies. In other words, "to be considered" materials (TBCs) are meant to complement the use of ARARs, not to compete with or replace them. Because TBCs are not ARARs, their identification and use are not mandatory.

certain portions of the Site. Some location-specific ARARs overlap with action-specific ARARs. Location-specific ARARs are listed in Table 4-3.

4.1.1 *Applicability of ARARs to the Final Remedy*

CERCLA Section 121 requires that the selected alternative must be protective of human health and the environment and meet ARARs, unless an ARAR is waived. The NCP provides that an ARAR may be waived under the circumstances provided in 40 CFR 300.430(f)(1)(ii)(C):

"*An alternative that does not meet an ARAR under federal environmental or state environmental or facility siting laws may be selected under the following circumstances:*

1. *The alternative is an interim measure and will become part of a total remedial action that will attain the applicable or relevant and appropriate federal or state requirement;*
2. *Compliance with the requirement will result in greater risk to human health and the environment than other alternatives;*
3. *Compliance with the requirement is technically impracticable from an engineering perspective;*
4. *The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach;*
5. *With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state; or*
6. *For Fund-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of Fund money to respond to other sites may present a threat to human health and the environment*."

The EPA OSWER Directive 9234.2-25 guidance titled, *Guidance for Evaluating Technical Impracticability of Ground-Water Restoration* (EPA 1993a) and OSWER Directive 9200.4-14 titled, *Consistent Implementation of the FY 1993 Guidance on Technical Impracticability of Ground-Water Restoration at Superfund Sites* (EPA 1995b) provide the primary guidance for technical impracticability (TI) waivers (TI guidance). The TI guidance requires a "TI evaluation", which must include the data and analyses necessary to make a TI determination. The TI guidance further states that the TI evaluation may be performed by the responsible parties at enforcement-led sites but that the TI determination will be made by EPA.

4.2 Preliminary Remedial Action Objectives (RAOs)

As described in the NCP (40 CFR 200) and in EPA's (1988b) *Guidance on Remedial Actions for Contaminated Ground Water at Superfund Site*, RAOs are medium-specific or site-specific goals for protecting human health and the environment. RAOs are established based on the nature and extent of contamination, the receptors that are currently and potentially threatened, and the potential for human and environmental exposure. PRGs are site-specific, quantitative goals that define the extent of cleanup required to achieve the RAOs (see Section 4.3). RAOs for the Site as defined by EPA (2010) are summarized below.[3]

One of the expectations to be generally considered by EPA is the ability of remedial alternatives to address principal threat wastes (PTWs) to the extent practicable (see Section 1.1). PTWs are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur (EPA 1991a). For the purposes of this FS, DNAPL, DNAPL-impacted soil, and DNAPL-impacted sediment (i.e., either oil-wetted or oil-coated materials[4]; also referred to as residual DNAPL or 'DNAPL-impacted' soil or sediment in this FS) are considered to be PTWs. The RAOs and remedial alternatives assembled in this FS use a wide range of removal, treatment, and containment strategies to address Site media, including PTWs. The NCP evaluation of individual alternatives and a comparative evaluation of alternatives are presented in Sections 7 and 8, respectively, in this FS Report.

4.2.1 *RAOs for Principal Threat Waste*

The RAOs for PTWs at the Site are:

- **SC1:** Treat or remove DNAPL in subsurface soils and groundwater to prevent contamination of groundwater above COC MCLs to the extent practicable (as defined in 40 CFR 300.430(a)(1)(iii)(A-F) of the NCP).
- **SC2:** Contain DNAPL in subsurface soils and groundwater where treatment or removal is not practicable (as defined in 40 CFR 300.430(a)(1)(iii)(A-F)of the NCP).

4.2.2 *RAOs for Soil*

The RAOs for soil address source control, human health protection, and environmental protection:

- **HH6:** Reduce to acceptable levels the human health risk from direct contact or incidental ingestion of COCs in surface and subsurface soil exceeding soil remediation goals.
- **SC3:** Reduce migration of COCs to groundwater from soils that exceed remediation goals for the protection of surface water.
- **EP2:** Reduce to acceptable levels the risk to terrestrial wildlife when direct contact and incidental ingestion or consumption of soil invertebrates results in exposures to COCs that exceed remediation goals.

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[3] The RAOs are grouped by media in this section of the FS. Codes refer to original groups: SC – source control; HH – human health; and EP – environmental protection.

[4] Refer to Section 4.3.1 of the RI Report (Anchor QEA and Aspect 2012) for description of "oil-wetted' and "oil-coated" materials with regard to DNAPL characterization.

4.2.3 *RAO for Groundwater*

The RAO for groundwater addresses human health protection:

- **HH1:** Restore groundwater to its highest beneficial use (drinking water) by meeting COC MCLs in the Site Shallow Alluvium and Deeper Alluvium aquifers within a reasonable period of time.

4.2.4 *RAOs for Sediment*

The RAOs for sediment address source control, human health protection, and environmental protection:

- **HH2:** Reduce to acceptable levels the risk to adults and children who ingest resident fish and shellfish taken from the Site for subsistence.
- **HH3:** Reduce to acceptable levels the human health risk from playing, wading, or swimming resulting in incidental ingestion or/and dermal exposure to contaminated sediments that exceed remediation goals.
- **SC4:** Reduce migration of COCs to surface water from sediments that exceed remediation goals for the protection of surface water.
- **EP3:** Reduce to acceptable levels the risk to aquatic-dependent wildlife (sediment probing birds and piscivorous mammals) and benthos where surface sediments containing COCs exceed remediation goals.[5]

4.2.5 *RAOs for Surface Water*

The RAOs for surface water address human health and environmental protection:

- **HH4:** Reduce to acceptable levels the human health risk from direct contact or incidental ingestion of surface water contaminated with COCs exceeding remediation goals (water quality standards or MCLs).
- **EP1:** Reduce to acceptable levels the risk to aquatic-dependent organisms when direct contact with surface water or incidental ingestion of COCs in surface water exceeds remediation goals (water quality standards).

4.2.6 *RAO for Vapor*

The RAO for vapor addresses human health protection:

- **HH5:** Reduce to acceptable levels the human health risk from inhalation of vapors from groundwater and/or soils contaminated with COCs exceeding soil or groundwater remediation goals.

4.3 Preliminary Remediation Goals (PRGs)

PRGs for groundwater, soil, air/vapor, surface water/porewater, and sediment were developed for those COCs that drive human health and/or ecological risks ("risk driver COCs") using chemical-specific ARARs, risk-based concentrations (RBCs), regional background data, and other appropriate EPA human health and ecological screening sources (EPA 2004a). For soil, surface water, and sediment, PRGs were developed for both human health and ecological exposure pathways. For groundwater/porewater and

[5] This RAO is modified to include risks to benthos, which was originally a separate RAO (EP4).

air/vapor, PRGs were developed for human health exposure only, because ecological exposures are not a risk driver for these pathways.

A detailed PRG evaluation was performed as part of the RI Report (Anchor QEA and Aspect 2012) for the purpose of determining the nature and extent of contamination. In the RI Report, PRG screening levels were identified for risk driver COCs based on the most relevant human health or ecological Site exposure pathway. For example, the development of the PRG screening levels prioritized: 1) MCLs above other ARARs or risk-based criteria; 2) groundwater criteria over surface water criteria for groundwater; and 3) surface water criteria over groundwater criteria for porewater, consistent with the RI Report (Anchor QEA and Aspect 2012).

PRGs have been identified for all risk driver COCs as the most stringent (lowest concentration) value within the following hierarchy, as directed by EPA:

- **Federal and Washington State ARARs.** If one or more chemical-specific ARARs (i.e., promulgated cleanup standards, such as an MCL) are available, the lowest value for a particular chemical and media was identified as the PRG.
- **Risk-Based Concentrations (RBCs).** RBCs were calculated using EPA screening levels (e.g., regional screening levels [RSLs] and ecological soil screening levels [SSLs]). Potential PRGs based on carcinogenic effects were calculated for elevated cancer risks of 1 x 10^{-4}, 1 x 10^{-5}, and 1 x 10^{-6}. Potential PRGs based on non-carcinogenic effects were calculated for a hazard quotient (HQ) of 1. If a chemical-specific ARAR is not available, for the purposes for this FS, the lowest RBC based on an elevated cancer risk of 1 x 10^{-6} or HQ of 1 was selected as the PRG. The exception is naphthalene in groundwater. The RBC at 1 x 10^{-5} was used to define the extent of the naphthalene plume.[6]

As discussed above, the results of the baseline ecological risk assessment indicate that risks to terrestrial invertebrates, plants, and wildlife (birds and mammals), as well as to benthic invertebrates, aquatic plants, and aquatic-dependent wildlife, exceed an HQ of 1. The primary contributors to unacceptable risk are PAHs, represented as both individual chemicals and as totals (LPAHs, HPAHs, total PAHs, and PAH ESBQs). While EPA surface water screening levels for ecological protection (Canadian Council of Ministers of the Environment 1999) were used in this FS to delineate sediment areas potentially

[6] The RBC for naphthalene is for the purposes of the FS only. Cleanup levels will be determined in the ROD. Table 4-7 shows the PRG for naphthalene based on risk of 10^{-6} is 0.14 μg/L. Of 154 detected naphthalene results for groundwater (representing multiple samples at the same location for some wells), only 2 results were detected at lower concentrations than 0.14 μg/L. Of the 33 non-detected naphthalene results, only 7 were lower. Therefore, a PRG of 0.14 μg/L is below most of the detection limits that were achievable during the RI. Naphthalene concentrations in the groundwater beneath the lake drop off fairly dramatically in the vicinity of the inner harbor line (based on well point comparisons – e.g., from 6,400 μg/L in WP-19B to 6.1 μg/L in WP-19C, and then 0.042 μg/L in WP-19D). The inner harbor line is also the furthest extent of upwelling groundwater from the site that is predicted by modeling. Therefore, a PRG of 1.4 μg/L best serves to estimate the naphthalene plume resulting from contamination at Quendall (as opposed to other potential sources).

requiring remediation (based on porewater concentrations), the PAH ESBQ dataset presented in the RI (Anchor QEA and Aspect 2012) provides a more scientifically robust means to evaluate ecological risks at the Site. Thus, a PAH ESBQ toxic unit (TU) criterion of 1 (Table 4-6) has been identified in this FS as the PRG for sediment porewater.

If the PRG was less than background, the PRG was adjusted to the background concentration[7]. PRGs for two soil COCs (arsenic and lead) were adjusted based on natural background concentrations for Puget Sound (Ecology 1994).

As discussed in Section 3.5, the approximate extent of surface sediment contamination requiring remediation is defined by a BTV of 17.5 mg/kg-OC. The BTV was developed based on an evaluation of cPAH sediment samples collected in the vicinity of the site that have concentrations of cPAH resulting from human activities that are unrelated to releases from the Site.[8] Offsite sediment samples to characterize local non-site-related cPAH concentrations were collected during the 2009 RI (Anchor QEA and Aspect 2012). These samples were collected because preliminary risk calculations for human consumption of fish from Lake Washington, based on available Lake Washington sediment data for cPAH (King County 2000) and conservative biota-sediment accumulation factors and EPA default shellfish ingestion rates, indicated an excess cancer risk in the range of 10^{-4} to 10^{-5}.

Because a risk-based PRG would be lower than these levels (especially if tribal fish consumption rates were used), an additional data collection effort was included in the Quendall RI (described as a "background study"). The revised State of Washington Sediment Standards (SMS) include definitions for, and the applicability of, both natural and regional background sediment concentrations for use in site characterization and cleanup efforts. At this time, there are no published natural or regional background values for Lake Washington. The purpose of the "background study" for Quendall was not intended to be used to define either natural or regional background as defined in the SMS.

Potential PRGs, including ARARs, RBCs, and background concentrations, are provided in Tables 4-4 through 4-7 for soil, groundwater, surface water/porewater, and sediment, respectively. The PRGs used in this FS according to the hierarchy described above are summarized in Table 4-8. The assumptions and other considerations used to identify the PRGs for each medium are summarized in Sections 4.3.1 through 4.3.5 below.

4.3.1 *Preliminary Remediation Goals for Soil*

Soil PRGs are summarized in Table 4-4. Soil risk driver COCs for human health are the PAHs 2-methylnaphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, and

[7] PRGs may also be adjusted to practical quantitation limits (PQLs); however, none of the PRGs for Site COCs exceeded PQLs so no adjustments based on PQLs were made.

[8] Per WAC 173-340-200 (Definitions): "Area background" means the concentrations of hazardous substances that are consistently present in the environment in the vicinity of a site which are the result of human activities unrelated to releases from that site.

naphthalene; the volatile organic compound (VOC) ethylbenzene; and arsenic. RBCs used for determining soil PRGs were calculated using the exposure assumptions of the human health risk assessment (HHRA) residential scenario. These inputs and corresponding PRGs are identical to the EPA RSLs.

For ecological receptors, risk driver COCs are chromium, lead, pentachlorophenol, and HPAHs, including the individual PAHs benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

Arsenic RBCs for human health are lower than background; therefore, the soil PRG for arsenic is based on natural background for Puget Sound (Ecology 1994).

4.3.2 *Preliminary Remediation Goals for Groundwater*

Groundwater PRGs are summarized in Table 4-5. As discussed in the RI Report (Anchor QEA and Aspect 2012), groundwater risk driver COCs for human health are as follows:

- **VOCs.** Benzene, ethylbenzene, and total xylenes;
- **SVOCs – PAHs.** 2-methylnaphthalene, acenaphthene, fluoranthene, fluorene, naphthalene, pyrene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene;
- **Other SVOCs.** Dibenzofuran; and
- **Metals.** Arsenic.

RBCs used for determining groundwater PRGs were calculated using the exposure assumptions of the HHRA residential scenario. These inputs and corresponding PRGs are identical to the EPA RSLs. Groundwater pathways are not complete to ecological receptors.

The drinking water MCL for arsenic is 10 µg/L (Table 4-5). Based on the natural background of arsenic in soil and its higher mobility under geochemically reducing conditions, naturally occurring organic materials, such as peat, can create groundwater conditions with naturally elevated arsenic concentrations.

4.3.3 *Preliminary Remediation Goals for Air and Vapor*

PRGs for indoor air and trench vapor (summarized in Table 4-8) were based on the EPA RSLs for residential air and industrial air, respectively. Indoor air and trench vapor risk driver COCs for human health are as follows:

- **VOCs.** Benzene, ethylbenzene, naphthalene, and total xylenes.

4.3.4 *Preliminary Remediation Goals for Surface Water/ Porewater*

Surface water/porewater PRGs are summarized in Table 4-6. The surface water/porewater risk driver COC for human health is as follows:

- **VOC.** Benzene, with the National Water Quality Criteria for human health (water+organism) used as the PRG.

For ecological receptors, risk driver COCs include:

- **PAHs.** 2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene, and PAH ESBQ TU; and
- **VOC.** Toluene.

As discussed above, ecological screening values from EPA Region 3 and EPA Region 5 were used as PRGs for individual chemicals to delineate sediment areas potentially requiring remediation. The PAH ESBQ applied in the RI (Anchor QEA and Aspect 2012) following EPA guidance (toxic unit [TU] = 1) was used in this FS to determine the protectiveness of alternative sediment cleanup actions (see Section 7.2.1).

4.3.5 *Preliminary Remediation Goals for Sediment*

Sediment PRGs are summarized in Table 4-7. Nearshore and Site-wide sediment risk drivers for human health are based on sediment exposure per the beach recreation and fishing scenarios, respectively. The human health risk driver COCs included:

- **PAHs.** Benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, and indeno(1,2,3-cd)pyrene.

For ecological receptors, the risk driver COCs include:

- **PAHs.** Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene.

As discussed in the RI Report (Anchor QEA and Aspect 2012), for the nearshore sediment, the otter was the most sensitive ecological receptor and PRGs were developed based on toxicity data for benzo(a)pyrene, total PAHs, and HPAHs. For the Site-wide sediment, the sandpiper was the most sensitive ecological receptor and PRGs were based on toxicity data for benzo(a)pyrene and total PAH. Toxicity to benthic invertebrates is also a risk driver, and the PRG is the PAH ESBQ (TU = 1).

Consumption of fish and shellfish is a risk driver for human health and ecological receptors, although this endpoint is based on modeled tissue concentrations from sediment using biota-sediment accumulation factors. The bioavailability of PAHs in sediment for uptake into fish or shellfish tissue is a function of OC content (total organic carbon [TOC] data for sediment samples are provided as a percentage and ranged from 0.178 percent up to 46.2 percent); therefore, the PRG for fish and shellfish consumption is expressed as an OC-normalized sediment concentration. The site-specific RBCs for cPAHs in surface sediment (Table 4-7) are based on fish consumption modeled using conservative biota-sediment accumulation factors and 99th percentile U.S. population fish/shellfish ingestion rates.[9] The RBC at 10^{-6} of 0.19 mg/kg-OC is approximately an order of magnitude lower than the lowest detected OC-normalized cPAH concentration in Lake Washington or Lake Sammamish (based on the most recent publically-available data [King County, 1999 and 2000]). As noted, the PRG is based on a conservative fish consumption rate estimate for the general U.S. population (an annualized rate of 143.4 grams per day, [EPA, 2002]); however, tribal consumption rates may be higher.

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[9] Using the same calculations and assumptions as the Baseline Human Health Risk Assessment in the Quendall RI Report (Anchor QEA and Aspect, 2012).

Therefore it is assumed that the 10^{-6} RBC for cPAHs in sediment is below natural and/or regional background for Lakes Washington and Sammamish. As noted above, neither natural nor regional background concentrations have been established for Lake Washington or Lake Sammamish. Therefore, a sediment cPAH BTV was used for the purpose of delineating the approximate extent of sediments that may require remediation based on a background-based criterion. The derivation of the BTV is described in Appendix B (B-1).

4.4 Site Areas and Media Targeted for Remedial Action

To identify Site areas to be remediated, areas containing PTW are first distinguished, followed by the areas of the Site with media that exceed PRGs. Site areas with DNAPL or with contaminant concentrations above PRGs in each Site media were identified based on the data presented in the RI Report (Anchor QEA and Aspect 2012). These Site areas are not meant to represent any particular priority for remediation but instead present a way to organize the Site for purposes of the FS.

Site Areas containing PTWs were differentiated by considering the following:

- **Effect on Shallow and Deep Aquifers.** Because of the shallow water table, most Site DNAPL is in contact with groundwater and is a source of groundwater contamination. As a result, groundwater in the Shallow Alluvium over most of the Site exceeds drinking water MCLs. Groundwater in a portion of the Deeper Alluvium is also contaminated above MCLs, but because of Site groundwater flow patterns (groundwater flows downward on the eastern portion of the Site and upward on the western portion of the Site), only a portion of the DNAPL source significantly impacts groundwater quality in the Deeper Alluvium. Distinct Site areas were identified that contain DNAPL that significantly impacts groundwater quality in the Deeper Alluvium. They are the RR DNAPL Area and the easternmost MC DNAPL Area (near MC-1).
- **DNAPL Depth.** DNAPL present at different depths may be best addressed by using different technologies. For example, remedial alternatives involving excavation of shallow DNAPL-impacted soil (e.g., in the top 10 to 15 feet) or shallow DNAPL-impacted sediments (e.g., in the top 5 feet) are easier to implement than remedial alternatives involving excavation of deep DNAPL-impacted soil (down to 34 feet bgs) or sediment (down to 16 feet bgs). Therefore, distinct Site areas containing DNAPL at significantly deeper depths were identified. They are the RR DNAPL Area, the easternmost MC DNAPL Area (MC-1), and the QP-S DNAPL Area.
- **DNAPL Mobility.** As described in Section 4 of the RI Report (Anchor QEA and Aspect 2012) and summarized above in Section 3.2, the majority of Site DNAPL is below residual saturation (i.e., oil-coated DNAPL) and is not expected to be mobile. DNAPL that is above residual saturation (i.e., oil-wetted DNAPL) is considered to be mobile even through low-permeability soil layers may stop, slow down, or alter the movement of DNAPL. It is possible that DNAPL that is currently impeded by low-permeability layers may still move, especially if subsurface conditions were to change (e.g., as part of remediation, as a result of future development activities, or following a large seismic event). Areas

containing a high percentage of oil-wetted DNAPL include the QP-U DNAPL Area and certain areas in the MC and QP-S DNAPL Areas.

- **DNAPL Cumulative Thickness**. Greater cumulative thicknesses of DNAPL (either oil-coated or oil-wetted) can contribute more significantly to groundwater contamination. Further, DNAPL residuals present as thin stringers have more surface area per volume of DNAPL; therefore, cumulative thicknesses that comprise multiple layers may impact groundwater as much or more significantly than contiguous DNAPL occurrences. Each of the upland sources have at least one occurrence of where DNAPL has been observed at a cumulative thickness of 4 feet or more.

Section 4.4.1 below discusses how the four considerations above were used to delineate specific DNAPL areas.

Areas outside the DNAPL footprint with media that exceed PRGs are described in Section 4.4.2 and are designated as follows:

- The Surface Soil Area;
- The Subsurface Soil and Groundwater Area; and
- The Surface and Subsurface Sediment Area.[10]

4.4.1 *DNAPL Areas*

This section describes how specific areas of DNAPL were delineated and differentiated based on their effect on groundwater quality, depth, mobility, and cumulative thickness. Specific DNAPL areas are generally defined based on occurrences that have a particular impact on groundwater quality (such as on the Deep Aquifer), have significant amounts of DNAPL above residual saturation (considered potentially mobile), are located at depths that are particularly shallow (in sediments) or deep (in the uplands), and/or have significant thicknesses of DNAPL-impacted soil. Table 4-9 provides a summary of the DNAPL depth, thickness, estimated volumes, and percent logged as oil-wetted by source area.

Specific DNAPL areas that are notable with respect to the above criteria include:

- **RR DNAPL Area:** DNAPL-impacted soil in the former Railroad Tank Car Loading Area (deep occurrence, maximum thickness, and potentially mobile);
- **MC DNAPL Area:** DNAPL-impacted soil in the former May Creek Channel (deepest occurrence, moderate thickness, and potentially mobile);
- **QP-U DNAPL Area:** DNAPL-impacted soil around Quendall Pond (deep occurrence, moderate thickness, and potentially mobile);
- **QP-S DNAPL Area:** DNAPL-impacted sediments offshore of Quendall Pond (moderate depth and thickness, and potentially mobile); and

[10] The surface sediment area includes characterization based on sediment porewater sampling and analysis.

- **TD DNAPL Area:** DNAPL-impacted sediments along the former T-Dock (shallow sediment depth and moderate thickness).

Areas with DNAPL at shallow to moderate depth in the uplands with fewer occurrences of oil-wetted DNAPL were grouped separately and are described as Other Upland or Aquatic DNAPL Areas, as they are more challenging to delineate individually and they share similar characteristics. These areas include DNAPL-impacted soil in other former process areas, specifically the Still House, the Boiler House, and the North and South Sumps). Many of the Other Upland DNAPL Areas contain DNAPL with significant cumulative thickness, one of the distinguishing criteria mentioned above.

Figures 4-2, 4-3, 4-4, and 4-5 depict cross sections for the delineated DNAPL areas shown on Figure 4-1. Refer to Figure 3-5 for boring locations discussed in this section. DNAPL depths, thicknesses, and characteristics at specific borings identified below are from Appendix G of the RI Report (Anchor QEA and Aspect 2012). The location and characteristics of each delineated DNAPL area are described below.

4.4.1.1 Railroad DNAPL Area (RR DNAPL Area)

The RR DNAPL Area is located in and around the former Railroad Tank Car Loading Area where liquid products (including coal tar and creosote) were historically loaded and unloaded on a trestle above the former May Creek Channel. As discussed in the RI Report (Anchor QEA and Aspect 2012), this area was reported to “have received heavy spilling over the years”. The trestle was located on the Railroad Property but, based on historical reports and Site investigation results, released products likely migrated west along the creek channel or in subsurface soil layers onto the Quendall Terminals Property. DNAPL in this upland area is of particular concern due to its effect on groundwater quality in the Deep Aquifer, depth, and thickness.

Site investigations identified significant quantities of DNAPL in the subsurface of this area, including one boring (Q2-D) with the largest cumulative thickness (11 feet thick) of DNAPL-impacted soil that has been observed at the Site, and boring BH-30C, where the deepest occurrence of DNAPL (33.7 feet bgs) was observed. Boring BH-30C is also the only location at the Site where DNAPL has been observed in the transition zone between the Shallow Alluvium and Deep Alluvium.

In this area, high concentrations of benzene (up to 1,600 µg/L), naphthalene (45,000 µg/L), cPAHs (2,760 µg/L[11]), and arsenic (1,690 µg/L) have been detected in groundwater in the Shallow Alluvium. The highest concentrations were detected at well Q9 (see Section 5.2 of the RI Report [Anchor QEA and Aspect 2012]). The deep DNAPL occurrences and downward hydraulic gradients in this area result in a groundwater plume extending into the Deep Aquifer (see Section 6 of the RI Report [Anchor QEA and Aspect 2012]).

The estimated lateral extent of the RR DNAPL Area is shown on Figures 4-1 and 4-3, and the vertical extent along Cross Section D-D’ is shown on Figure 4-5. Based on the available data, the RR DNAPL Area appears to be contiguous with DNAPL identified in the former May Creek Channel south of the former Still House, adjacent to former

[11] cPAH concentrations provided in Section 4.4.2 are the total benzo(a)pyrene TEQ for all cPAHs using mammalian toxicity equivalent factors.

storage tanks 1 through 5 (see Figure 3-5). However, DNAPL west of BH-30C (at borings HC-5, MC-20, and MC-23) was identified at shallow depths (less than 13 feet bgs) and over a smaller cumulative thickness (2.5 feet at each boring) than in BH-30C. Therefore, the western boundary of the RR DNAPL Area is estimated to be between the deep DNAPL occurrences at BH-30C and the shallow DNAPL occurrences at HC-5, west of BH-30C[12]. DNAPL occurrences west of the RR DNAPL Area are included in the "Other Upland DNAPL Areas" described in Section 4.4.2.4 below.

4.4.1.2 Former May Creek Channel DNAPL Area (MC DNAPL Area)

The MC DNAPL Area is located where wastes containing creosote were reportedly discharged from the plant through a sewer outfall to the former May Creek Channel (Roberts 1989). DNAPL in this upland area is of particular concern due to its mobility, depth, and thickness. Site investigations identified significant quantities of DNAPL, including one boring (MC-1, located adjacent to the former sewer outfall) where the greatest depth (to a maximum depth of 31.5 feet bgs) has been observed outside of the RR DNAPL Area.

DNAPL occurrences in this area extend west of the former outfall along the former channel alignment. At well BH-21A, located in the former May Creek Channel downstream of the outfall, 5.5 feet of DNAPL accumulated and returned (i.e., recovered) after purging the well, indicating that DNAPL at this location is above residual saturation (i.e., oil-wetted soil). In total, 35 gallons of creosote DNAPL were removed from this well during DNAPL recovery pilot testing in 2003 and 2004. DNAPL-impacted soil was also observed at borings MC-8 (1.5 feet thick) and MC-7 (1 foot thick), located progressively west of BH-21A. A 0.2-foot-thick layer of DNAPL-impacted soil was observed at MC-16, located west of MC-7. DNAPL has not been observed in sediment borings immediately downgradient of the MC DNAPL Area (though the nearest sediment boring, VS-9, is located approximately 100 feet from MC-16). It is uncertain whether DNAPL has migrated offshore in this area; therefore the extent of DNAPL in this area is conservatively depicted as extending offshore approximately half the distance between these two sampling locations (Figure 3-5).

In the easternmost MC DNAPL Area (Figure 3-5), contaminants are transported from the DNAPL-impacted soils near the base of the Shallow Aquifer at MC-1 into the top of the Deep Aquifer because of the slightly downward vertical gradient in this area. This contributes to the groundwater plume extending into the Deep Aquifer (see Section 6.4.2 of the RI Report [Anchor QEA and Aspect 2012]). In the western part of the MC DNAPL Area, high concentrations of naphthalene (up to 2,100 µg/L) have been detected in groundwater, with the highest concentrations at well BH-21A. Benzene (up to 16 µg/L at BH-21B), cPAHs (24.6 µg/L at BH-21A), and arsenic (109 µg/L at BH-21B), have also been detected above their respective PRGs. Near the shoreline, groundwater flow transitions upward, resulting in an elevated concentration of naphthalene (4,100 µg/L) in offshore subsurface groundwater at wellpoint WP-21C.

[12] The boundary for each area is based on the available data for the purposes of developing and comparing alternatives. Additional characterization of the actual area boundary may be performed as part of the remedial design, if necessary.

The vertical extent of the MC DNAPL Area along Cross Section B-B’ is shown on Figure 4-3. The MC DNAPL Area consists of three separate areas where deep DNAPL or significant thicknesses of DNAPL-impacted soil were identified: 1) near the former sewer outfall, at boring MC-1; 2) downstream of the former sewer outfall at boring HC-7, where a 6.5-foot-thick layer of DNAPL-impacted soil was observed; and 3) still further downstream at monitoring well BH-21A and borings MC-7 and MC-8. DNAPL was also observed at several adjacent locations: MC-2 (southwest of MC-1), MC-13 (north of MC-1), SP-1 (west of MC-1), and MC-16 (west of MC-8); however, occurrences of DNAPL-impacted soil were limited to very thin layers (0.5 foot thick at MC-2, 0.3 foot thick at MC-13, and 0.2 foot thick at MC-16). These more limited DNAPL occurrences are included in the Other Upland DNAPL Areas (Section 4.4.1.4).

4.4.1.3 Quendall Pond Upland DNAPL Area (QP-U DNAPL Area)

The QP-U DNAPL Area is located where tank bottoms were reportedly placed (Roberts 1989) and where contaminated fluids discharged to the North Sump migrated via surface or subsurface flow (see RI Report Section 4.4.4 [Anchor QEA and Aspect 2012]). DNAPL in this upland area is of particular concern due to its effect on shallow groundwater quality and its mobility (it contains the highest percentage of upland DNAPL logged as oil-wetted, Table 4-9).

Site investigations in this area identified DNAPL-impacted soil in the subsurface, including at two wells from which DNAPL was recovered during pilot testing in 2003 and 2004, as follows:

- **Well BH-5, located just east of Quendall Pond**. At this well, 1 foot of DNAPL-impacted soil, to a maximum depth of 19 feet bgs, was observed, and 26 gallons of DNAPL were recovered during pilot testing.
- **Well RW-QP-1, located just west of Quendall Pond.** At this well (co-located with boring SP-3), 2 feet of oil-wetted soil, to a maximum depth of 16 feet bgs, was observed, and 42 gallons of DNAPL were recovered during pilot testing.

DNAPL-impacted soil has also been observed at several other borings adjacent to Quendall Pond, including SP-4 (1 foot thick, to a depth of 12.5 feet bgs), SP-8 (1.4 feet thick, to a depth of 18 feet bgs), and RB-12 (0.4 foot thick, to a depth of 18 feet bgs).

In this area, high concentrations of naphthalene (up to 16,000 µg/L), benzene (up to 33,000 µg/L), and cPAHs (up to 362 µg/L) have been detected in the Shallow Aquifer, with the highest concentrations at well BH-5. Arsenic (up to 53.8 µg/L at BH-5A) has also been detected above its PRG. The deepest DNAPL occurrence in this area (at BH-20C, where DNAPL-impacted soil [oil-coated] was observed from 25.5 to 26.5 feet bgs) is within the Shallow Alluvium, and groundwater flow is upward at this location; therefore it is not likely impacting the Deep Aquifer; however, based on contaminant transport via diffusion and dispersion and from contributions from DNAPL sources east of this area (RR Area and the easternmost MC DNAPL Area [MC-1], see Section 6 of the RI Report [Anchor QEA and Aspect 2012]), concentrations of benzene and naphthalene (and to a lesser extent, arsenic) are also elevated at the top of the Deep Aquifer.

The QP-U DNAPL Area includes the locations where oil-wetted soil was identified around Quendall Pond. DNAPL was also observed at locations north, south, east, and west of this area but because of distinguishing characteristics, these adjacent occurrences were not included in the QP-U DNAPL Area, but were included in Other DNAPL Areas (below), as follows:

- **To the North.** DNAPL was not observed at well BH-19 but was identified north of BH-19 at borings SP-2, QP-1, and RB-11 and sediment cores VS2, QPN-07, and NS15. DNAPL layers to the north of Quendall Pond get progressively thinner and lower in elevation, tapering to a 0.1-foot-thick layer of DNAPL-impacted sediment 9.3 feet below mudline at NS15.
- **To the South.** DNAPL was identified at BH-20C, from a depth of 25.5 to 26.5 feet. However, this occurrence was characterized as oil-coated rather than oil-wetted.
- **To the East.** DNAPL has been identified in soil borings east of Quendall Pond, in the vicinity of the North Sump; however, the physical and chemical characteristics of DNAPL near the North Sump are distinct from the DNAPL characteristics at Quendall Pond as follows:
    - DNAPL near the North Sump is below residual saturation and was not recoverable during the DNAPL recovery pilot test.
    - DNAPL near the North Sump has a much lower concentration of benzene (approximately 0.06 percent by weight: see RI Report Table 4.2-1 [Anchor QEA and Aspect 2012]) than DNAPL near Quendall Pond (up to 1 percent by weight).
- **To the West.** DNAPL has been identified in sediment borings offshore of Quendall Pond. Because sediment remediation technologies and methods are often significantly different from upland technologies, offshore DNAPL occurrences are discussed separately.

4.4.1.4 Other Upland DNAPL Areas

The Other Upland DNAPL Areas are shown on Figure 4-1, and include all upland areas where DNAPL was observed (at any thickness) outside of the specific areas discussed above (i.e., RR DNAPL Area, MC DNAPL Area, and QP-U DNAPL Area). The Other Upland DNAPL Areas generally contain DNAPL that is shallow, thin layered, and/or below residual saturation (i.e., oil-coated DNAPL), but may be present at significant cumulative thickness. While DNAPL in these areas likely do not significantly impact groundwater quality in the Deep Aquifer, they comprise an ongoing significant source of contamination to the Shallow Aquifer.

4.1.1.1.1 DNAPL in Other Former Process Areas

Upland occurrences of DNAPL not associated with the former railroad tank car loading, May Creek channel, or Quendall Pond areas are generally associated with three other former process areas: 1) the Railroad Solid Materials Loading Area; 2) the Still House; and 3) the North Sump. Cumulative thickness of DNAPL is an important differentiator within these areas. Figure 4-6 shows the DNAPL cumulative thicknesses observed in Site borings, depicted using Thiessen polygons.13

DNAPL characteristics in these areas are summarized as follows:

- **Former Railroad Solid Materials Loading Area.** DNAPL in this area occurs at depths less than 22 feet bgs, primarily as oil-coated soil. It does not appear to have a significant impact on groundwater quality (as measured at wells Q1-D and BH-27), likely because of the composition of the material (i.e., a higher proportion of heavier PAH compounds than elsewhere on the Site, with no BTEX compounds detected). The largest cumulative thickness of DNAPL observed was 6 feet (at Q1-D).
- **Former Still House.** DNAPL at this location occurs at depths less than 14 feet bgs. DNAPL layer thickness observations did not exceed 2 feet except at BH-8, where a 4-foot thickness was observed from in a silty sand layer from 8.5 to 12.5 feet bgs. (This was also the largest cumulative DNAPL thickness observed in this area.) Well BH-8A was installed with the screen placed from 13 to 23 feet bgs (the top of the screen beginning in a 2-foot silty clay layer beneath the silty sand), and no product was recorded in this well. DNAPL in BH-8A was characterized as abundant brown fluid, but interpreted as oil-coated due to lack of product in the well (though this characterization is uncertain).
- **Former North Sump.** DNAPL in this area is present over a greater horizontal and vertical extent than the two “Other Former Process Areas” above, and occurs as deep as 24 feet bgs (at BH-23), with the largest accumulation observed at 6 feet (SP-5), characterized as dark brown free product. Most other DNAPL in this area has been identified as oil-coated, except for HC-2 (characterized as “saturated with yellowish viscous product” from 11.2 to 15.1 feet bgs), SWB-4 (characterized as “yellow-brown foamy sheen observed on auger” from 12.5 to 14 feet bgs), and SWB-4a (characterized as oil-wetted from 10 to 11 feet bgs). Product has not accumulated in two wells installed in this area (BH-23 [screened from 6 to 21.5 feet bgs] and RW-NS-1 [installed adjacent to SP-5 and screened from 6.5 to 16.5 feet bgs]), and maximum concentrations of benzene (350 µg/L at BH-23) and naphthalene (760 µg/L at RW-NS-1) in groundwater are more than 10 times lower than in the adjacent QP-U DNAPL Area to the west.

Refer to Section 4.4 of the RI Report (Anchor QEA and Aspect 2012) for additional information regarding DNAPL characteristics in the former process areas.

The cumulative thickness of DNAPL is an important differentiator within the Other Upland DNAPL Areas. Figure 4-6 shows the DNAPL cumulative thicknesses observed in

[13] The same cumulative thicknesses and Thiessen polygons were used in the RI Report (Section 4.4 and Appendix G) to estimate the cubic yards of DNAPL-impacted soil and sediment, and the gallons of DNAPL present in the subsurface at the Site.

Site borings, depicted using Thiessen polygons.[14] The maximum cumulative DNAPL thickness within the Other Upland DNAPL Areas is 6 feet at Q1-D and SP-5.

4.4.1.5 Quendall Pond Sediment DNAPL Area (QP-S DNAPL Area)

This area, labeled QP-S on Figure 4-1, is located where DNAPL near Quendall Pond has migrated offshore into subsurface sediments through permeable soil layers. DNAPL in this offshore area is of particular concern due to its effect on groundwater quality beneath the lake, thickness, and potential mobility ((it contains the highest percentage of DNAPL logged as oil-wetted, Table 4-9).

This area includes two sediment boring locations where DNAPL-impacted sediment has been observed: at VS-30 (5 feet thick [oil-wetted], to a depth of 9 feet below mudline) and QPN-02 (cumulative thickness of 1.7 feet [mostly oil-wetted], to a depth of 7.4 feet below mudline). This area is a continuation of the QP-U DNAPL Area described above but is discussed separately because different remedial technologies may be applied to sediments than to upland soils.

Groundwater in this area contains relatively high concentrations of benzene (up to 11,000 µg/L, at wellpoints WP-19A and WP-19B) and naphthalene (up to 11,000 µg/L, at wellpoint WP-3). Concentrations of cPAHs (up to 12.5 µg/L at wellpoint WP-3) have also been detected above the PRG (WP-3 is in the vicinity of VS-30).

A thin layer of oil-coated DNAPL-impacted sediment was also observed at three sediment borings north of this area, at QPN-07 (0.2 foot thick, to a maximum depth of 8.7 feet below mudline), VS-2 (2 inches thick, to a maximum depth of 16.3 feet below mudline), and NS-15 (0.1 foot thick, to a maximum depth of 9.3 feet below mudline). Because these DNAPL occurrences were relatively thin and below residual saturation (oil-coated) and are located where surface sediments and groundwater porewater are below PRGs, this area is discussed under Other Aquatic DNAPL Areas described in Section 4.4.1.7.

4.4.1.6 T-Dock DNAPL Area (TD DNAPL Area)

This area, labeled TD on Figure 4-1, is located along the former T-Dock alignment where historical spills from transfer piping have resulted in DNAPL occurrences in surface and subsurface sediments. DNAPL in this area is of particular concern due to its relatively shallow depth in sediments.

DNAPL in this area has been characterized as DNAPL-impacted sediment and has generally been observed in thin (1- to 4-inch-thick) layers. The TD DNAPL Area also includes thicker sequences of DNAPL observed at two sediment borings (1 foot thick at VT-1 [characterized as black oil, product sludge] and 3.8 feet thick at VT-4 [characterized as visible drops of product]) located west of the T-Dock cross-span, near the location of a major coal-tar release reported in the 1930s (Roberts 1989). DNAPL at these two locations was in surface sediment.

[14] The same cumulative thicknesses and Thiessen polygons were used in the RI Report (Section 4.4 and Appendix G) to estimate the cubic yards of DNAPL-impacted soil and sediment, and the gallons of DNAPL present in the subsurface at the Site.

PAHs (including naphthalene, cPAHs, and PAH TUs) were elevated above PRGs at locations TD-08 and TD-15 (at the end of the T-Dock), and at NS-12 (adjacent to boring VS-27). Midge and amphipod bioassay tests on samples from TD-08 and TD-15 resulted in mortality of the test organisms. Bioassay test samples from NS-12 were also classified as toxic.

4.4.1.7 Other Aquatic DNAPL Areas

Other Aquatic DNAPL Areas are shown on Figure 4-1 and consist of aquatic lands containing DNAPL that are not included in one of the two specific areas described above.

These other areas contain relatively thin layers of DNAPL (refer to Figure 4-6), that are generally below residual saturation (one extremely thin [0.01 foot] oil-wetted layer in TD-01). They are located north of the QP-S DNAPL Area and west (offshore) of the MC DNAPL Area.

4.4.1.8 Key Factors Influencing DNAPL Remediation

Key factors influencing the remediation of DNAPL at the Site are as follows:

- EPA has determined that DNAPL at the Quendall Site, whether in soils or sediments, is to be considered as PTW because of the high level of toxicity inherent in the creosote/coal tar DNAPL. Creosote/coal tar contaminants present in DNAPL (benzene and naphthalene) are also highly leachable and mobile via groundwater, and DNAPL classified as oil-wetted may be also be mobile.
- DNAPL at the Site cannot be reliably contained because any vertical barrier/treatment wall that would be installed at the Site could only be a “hanging” wall. There is no aquitard in which to anchor a barrier/treatment wall.
- DNAPL is accessible. The majority of DNAPL in the uplands is found within the top 20 feet of the Shallow Aquifer with two exceptions (RR Area and Former May Creek Channel).

4.4.2 *PRG Exceedance Areas*

This section describes the Site surface soil, subsurface soil and groundwater, and surface and subsurface sediment areas where PRGs are exceeded. These areas define the extent of the “Site”.

4.4.2.1 Surface Soil Area

The Surface Soil Area is the upland area outside where DNAPL has not been identified. It is that portion of the upland part of the Site not included in the DNAPL area (Figure 4-1). Although only limited surface soil sampling and analysis have been performed, the available data indicate that surface soils (i.e., soils in the 0- to 5-foot depth range) in this area exceed PRGs naphthalene, cPAHs, and arsenic (see Section 5.3 of the RI Report [Anchor QEA and Aspect 2012]).

An extensive data collection effort for the soil surface was not conducted for the RI/FS because:

- The Site is fenced, has been re-seeded, and access is prohibited.

- Future Quendall Terminals Property redevelopment, expected to follow completion of site remediation, will require at least several feet of fill to match the adjacent property grades and to install a gravity sewer system.
- Recent log sorting yard operations deposited a significant quantity of wood debris that is not representative of prior industrial activities. As a result, it is not certain whether there are still areas exceeding PRGs. Redevelopment plans will likely require that this material be removed or graded prior to paved-road construction, to minimize the potential for future settlement.
- Once the preferred remedy is identified, additional focused surface soil sampling and analysis can be completed if necessary to complete the remedial design.

The Surface Soil Area includes the upland portion of the Quendall Terminals Property and a portion of the adjacent Railroad Property. The Surface Soil Area on the Railroad Property includes the former Railroad Tank Car Loading Area and the Solid Materials Loading Area. Due diligence investigations performed by the Port of Seattle prior to purchasing the Railroad Property indicated that some Site COCs, including PAHs, arsenic, and lead, were detected outside of these two loading areas, but at concentrations and with a PAH fingerprint that is more consistent with contamination detected elsewhere along the Railroad Property away from the Site (Pinnacle Geosciences 2009).

4.4.2.2 Subsurface Soil and Groundwater Area

The Subsurface Soil and Groundwater Area, shown on Figure 4-1 as a dashed green line, is defined by the area where soils below the 5-foot depth and/or groundwater exceeds PRGs for Site COCs. The reason these are considered together is that the plume also contaminates the soil and vice versa since the water table is high. In general, the estimated lateral and vertical boundaries were delineated based on the maximum extent of naphthalene, which is the most widely detected COC above PRGs. As described in Section 3.5, the naphthalene PRG of 1.4 µg/L is slightly exceeded at wells along the north and south Quendall Terminals Property lines, at deep well BH-20C, and at background well BH-22, located east of Hazelwood Lane. For purposes of the FS, the boundaries of the Subsurface Soil and Groundwater Area are assumed to be as follows:

- The north and south Quendall Terminals Property boundaries are the north and south Site boundaries. Properties to the north (Football Northwest Property) and south (Barbee Mill Property) were or are being remediated and are subject to Environmental Covenants that restrict the use of groundwater.
- The eastern boundary is estimated to be the eastern boundary of the Railroad Property because groundwater flows to the west and there are no known sources to the east of the Railroad Property.
- The western boundary is estimated to be beneath Lake Washington as shown on Figure 4-1. This boundary is the maximum westerly extent of COCs exceeding PRGs (see Figure 3-6).
- The vertical extent of contamination exceeding PRGs below well BH-20C is estimated to be above the low-permeability lacustrine silt layer that bounds the Deep Aquifer. The vertical extent of the Subsurface Soil and Groundwater Area

along Cross Section D-D’ is approximated by the estimated extent of groundwater and porewater exceeding the naphthalene PRG on Figure 3-8.

4.4.2.3 Surface and Subsurface Sediment Area

The Surface and Subsurface Sediment Area is the area where surface sediment (0 to 4 inches below sediment surface [bss]) and subsurface sediments (deeper than 4 inches bss) exceed PRGs, as shown on Figure 4-1. The surface sediment area encompassed by cPAH BTV exceedances (defining the sediment remediation footprint for the FS) includes the areas that exceed naphthalene and PAH TU PRGs. Subsurface sediment areas associated with the T-Dock that exceed PRGs are encompassed by DNAPL areas. In the nearshore groundwater discharge area, subsurface sediment porewater exceeding the naphthalene PRG encompasses the area exceeding the benzene, cPAH, and PAH TU PRGs.

Table 4-1 Key Chemical-Specific ARARs for Remedial Action at the Quendall Terminals Site

Quendall Terminals
Renton, Washington

Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
Safe Drinking Water Act	Federal Primary Drinking Water Standards - Maximum Contaminant Levels (MCLs) and MCL Goals (MCLGs)	42 USC 300f, 40 CFR Part 141, Subpart O	Establishes drinking water standards for public water systems to protect human health. Includes standards for the following Site COCs: arsenic, benzene, and benzo[a]pyrene (B[a]P). The NCP states that MCLs, not MCLGs, are ARARs for usable aquifers.	ARARs for groundwater that could potentially be used for drinking water, where the water will be provided directly to 25 or more people or will be supplied to 15 or more service connections.
To Be Considered (TBC) for groundwater that could potentially be a drinking water source (i.e., achieved as practicable).	Federal Secondary Drinking Water Standards - Secondary MCLs	42 USC 300f, 40 CFR Part 143	Establishes drinking water standards for public water systems to achieve the aesthetic qualities of drinking water (secondary MCLs).	
ARARs for surface water if more stringent than promulgated state criteria.	Federal Ambient Water Quality Criteria	33 USC 1311 -1317; 40 CFR Part 131	Under Clean Water Act Section 304(a), minimum criteria are developed for water quality programs established by states. Two kinds of water quality criteria are developed: one for protection of human health, and one for protection of aquatic life. The federal recommended water quality criteria are published on EPA's website: http://water.epa.gov/scitech/swguidance/standards/current/index.cfm	
Surface Water Quality Standards	State Ambient Water Quality Criteria	Chapter 90.48 RCW; Chapter 173- 201A WAC	Establishes Water Quality Standards for protection of human health and for protection of aquatic life (for both acute and chronic exposure durations).	ARARs for surface water where Washington State has adopted, and EPA has approved, Water Quality Standards.

Table 4-1 Key Chemical-Specific ARARs for Remedial Action at the Quendall Terminals Site

Quendall Terminals
Renton, Washington

Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
Model Toxics Control Act	State Soil, Air, Groundwater, and Surface Water Cleanup Standards	Chapter 70.105D RCW; Chapter 173-340 WAC	Establishes cleanup levels for Site groundwater, surface water, soil, and air, including rules for evaluating cross- media protectiveness. MTCA cleanup levels cannot be set at concentrations below natural background.	Promulgated numeric cleanup levels are ARARs for soil, air, groundwater, and surface water. Equations to develop cleanup levels are not ARARs.
Model Toxics Control Act	Protection of Terrestrial Plants and Animals	"Terrestrial Ecological Evaluation Procedures" (WAC 173-340-7490) Site-Specific Terrestrial Ecological Evaluation Procedures" (WAC 173- 340-7493) Priority Contaminants of Ecological Concern (WAC 173-340-7494)	Establishes Site-specific cleanup standards for the protection of terrestrial plants and animals	ARARs for developing and evaluating cleanup action alternatives and in selecting a cleanup action under WAC 173-340-350 through 173-340-390.
EPA Guidance	Protection of Terrestrial Plants and Animals	Guidance for Developing Ecological Soil Screening Levels (OSWER Directive 9285.7-55)	Describes the process used to derive a set of risk-based ecological soil screening levels (Eco-SSLs) for many of the soil contaminants that are frequently of ecological concern for plants and animals at hazardous waste sites, and provides guidance for their use.	To Be Considered (TBC) guidance. The Eco-SSLs are not designed to be used as cleanup levels, and EPA emphasizes that it is inappropriate to adopt or modify the Eco- SSLs as cleanup standards.
Sediment Management Standards	State Sediment Quality Criteria	Chapters 90.48 & 70.105D RCW; Chapter 173-204 WAC	Establishes numerical standards for the protection of benthic invertebrates in marine and freshwater sediments.	Promulgated numeric cleanup levels are ARARs for freshwater sediments.

Table 4-2 Key Action-Specific ARARs for Remedial Action at the Quendall Terminals Site

Quendall Terminals
Renton, Washington

Remedial Activity	Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
Soil Excavation and Upland Filling	Solid Waste Disposal Act	Management and disposal of solid waste	42 USC 6901-6917; 40 CFR 257-258	Establishes requirements for the management and disposal of solid waste.	ARAR for remedial actions that result in upland disposal of excavated or dredged material.
	Resource Conservation and Recovery Act (RCRA); Washington Hazardous Waste Management Act and Dangerous Waste Regulations	Generation and Management (Transportation, Treatment, Storage and Disposal) of Hazardous Waste; Off-Site Land Disposal Considerations	42 USC 6921-22; 40 CFR Parts 260, 261 & 268; Chapter 70.105 RCW; Chapter 173-303 WAC (Chapter 173-307 WAC Pollution Prevention Plans is a TBC)	Defines solid wastes subject to regulation as hazardous wastes. Requires management of hazardous waste from "cradle to grave" unless exemption applies.	Potential ARAR for DNAPL and soils/ sediments excavated from the Site for off- site disposal, and a TBC for on-site stabilization actions. Recovered DNAPL that designates as hazardous waste would require additional management during handling (e.g., secondary containment), and may also be subject to land disposal requirements (e.g., pre- treatment prior to disposal). EPA determined that soils excavated above the water table in the former footprint of the North and South Sumps may designate as K035 waste (see EPA 2012) DNAPL, soil and/or sediment excavated and removed from the Site may also be a characteristic hazardous waste if it exhibits one of the characteristics defined in 40 CFR Part 261 Subpart C or in State Dangerous Waste Regulations. Excavated soils and/or sediment that exceed toxicity characteristic leaching procedure (TCLP) criteria must be managed as a hazardous waste and must meet the land disposal restriction treatment standards for contaminated soil (40 CFR 268.49). The treatment standard is the higher of a 90% concentration reduction or 10 times the universal treatment standard.

Table 4-2 Key Action-Specific ARARs for Remedial Action at the Quendall Terminals Site

Quendall Terminals
Renton, Washington

Remedial Activity	Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
	Hazardous Materials Transportation Act	Transport of Hazardous Materials	49 USC 5101 et seq.; 49 CFR Parts 171-177	Establishes requirements for transport of hazardous materials.	ARAR for those hazardous materials (e.g., DNAPL) transported off site.
	Off-Site Rule	Disposal of CERCLA Wastes	40 CFR 300.440	Requires disposal of CERCLA wastes at a facility operating in compliance with RCRA.	ARAR for remediation wastes transported off site.
Soil Excavation and Upland Filling	Washington Hydraulics Code	Filling of Wetlands	Chapters 75.20 & 77.55 RCW; Chapter 220-110 WAC	Establishes requirements for performing work that would alter existing jurisdictional wetlands.	ARAR if remedial actions such as excavation or capping impact existing jurisdictional wetlands. Remedial actions must result in no net loss of aquatic habitat and function after sequential consideration of avoidance and mitigation, allowing for site-specific evaluations of existing wetland functions.
	National Environmental Policy Act (NEPA) and State Environmental Policy Act (SEPA)	Construction Activities, Including Grading and Filling	40 CFR 1500-1508; Chapter 43.21C RCW; Chapter 197-11 WAC	Requires agencies to consider environmental impacts of a proposal.	ARAR for remedial activities that include excavation or filling.
	Washington State Shoreline Management Act; Wetlands in Washington State	Establishes requirements for work within the identified shoreline zone. Filling wetlands Wetland Mitigation Requirements Including Mitigation Ratios, Wetland Buffer and Setback Requirements	Chapter 90.58 RCW; Chapter 173- 26 WAC;	Establishes replacement requirements for wetlands affected by remedial actions to ensure no net loss of existing wetland acreage and functions; also establishes requirements for buffers and setbacks from shorelines and wetlands, including replacement wetlands.	ARAR if remedial actions such as excavation or capping impact existing jurisdictional wetlands. Remedial actions must result in no net loss of aquatic habitat and function after sequential consideration of avoidance and mitigation, allowing for site-specific evaluations of existing wetland functions.

Table 4-2 Key Action-Specific ARARs for Remedial Action at the Quendall Terminals Site
Quendall Terminals
Renton, Washington

Remedial Activity	Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
Soil Excavation and Upland Filling	Wetland Mitigation in Washington	Mitigation for filling wetlands	Ecology Publication 06-06-011a	Requirements for wetland mitigation by wetland delineation and ranking, such as buffer sizes, mitigation ratios, etc.	TBC for specific mitigation parameters
Dredging, Capping, and/or Discharge to Lake Washington	Clean Water Act	Federal Ambient Water Quality Criteria	33 USC 1311 - 1317; 40 CFR Part 131	See Table 4-1. Regulates activities which may result in discharges into navigable waters.	ARAR for control of short-term impacts to surface water from implementation of remedial actions that include dredging, capping, and discharge of treated water into Lake Washington. Incorporates the substantive provisions of relevant and appropriate Joint Aquatic Resources Permit Application (JARPA), Nationwide Permit, and stormwater regulation requirements.
	Surface Water Quality Standards	State Ambient Water Quality Criteria	Chapter 90.48 RCW; Chapter 173- 201A WAC	See Table 4-1. Regulates activities which may result in discharges into navigable waters.	ARAR for control of short-term impacts to surface water from implementation of remedial actions that include dredging, capping, and discharge of treated water into Lake Washington. Incorporates the substantive provisions of relevant and appropriate requirements, where Washington State has adopted and EPA has approved Water Quality Standards.
	National Pollutant Discharge Elimination System	Discharge of Pollutants into Lake Washington	40 CFR Part 122; Chapter 90.48 RCW; Chapter 173-226 WAC	Permitting system for discharging pollutants into waters of the United States.	ARAR for discharge of treated water to Lake Washington.
	Clean Water Act	Discharge of Materials into Lake Washington	33 USC 1344; 40 CFR Part 230	Regulates discharge of dredged and fill material into navigable waters of the United States.	ARAR for dredging and capping activities in Lake Washington.

Table 4-2 Key Action-Specific ARARs for Remedial Action at the Quendall Terminals Site

Quendall Terminals
Renton, Washington

Remedial Activity	Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
	Fish and Wildlife Coordination Act	Discharge of Materials, Impoundment or Diversion of Waters in Lake Washington	16 USC 662 & 663; 40 CFR 6.302(g)	Requires federal agencies to consider effects on fish and wildlife from projects that may alter a body of water and mitigate or compensate for project- related losses, which includes discharges of pollutants to water bodies.	ARAR for in-water remedial actions or if treated water is discharged into Lake Washington.
Dredging, Capping, and/or Discharge to Lake Washington	Washington Hydraulics Code	Filling in Lake Washington	Chapter 75.20 & 77.55 RCW; Chapter 220-110 WAC	Establishes requirements for performing work that would use, divert, obstruct, or change the natural flow or bed of Lake Washington.	ARAR for shoreline excavation, dredging, and/or capping actions. Remedial actions must result in no net loss of aquatic habitat or function after sequential consideration of avoidance and mitigation.
	River and Harbors Act	Placement of Structures in Lake Washington	33 USC 401 et seq.; 33 CFR 320-330	Prohibits the unauthorized obstruction or alteration of any navigable water. Establishes requirements for structures or work in, above, or under navigable waters.	ARAR for remedial actions in Lake Washington.
Well-Related Activities	Washington Water Well Construction Act	Monitoring Wells	"Water Well Construction Act of 1971" (Chapter 18.104 RCW, as amended); "Minimum Standards for Construction and Maintenance of Wells" (Chapter 173-160 WAC)	Establishes minimum standards for construction and maintenance of wells.	ARAR for monitoring well design, construction, development, and abandonment. Also provides technical standards by which well cuttings and development water are handled.

Table 4-2 Key Action-Specific ARARs for Remedial Action at the Quendall Terminals Site

Quendall Terminals
Renton, Washington

Remedial Activity	Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
Other Remedial Activities	Federal Clean Air Act; Washington Clean Air Act; Puget Sound Clean Air Agency (PSCAA) Regulations	Air Emission Discharges	42 USC §7401 et seq.; Chapter 70.94 RCW; Chapter 173-400 WAC; WAC 173-460 Controls for New Sources of Toxic Air Pollutants; WAC 173-470 Ambient Air Quality Standards for Particulate Matter; PSAPCA Regulation III	Regulates air emission discharges.	ARAR for remedial activities that generate fugitive dust or other air emissions, including treatment operations.
	Historic Preservation Act; Washington Historical Activities Act	Alteration of Historic Properties	16 USC 470 et seq.; 36 CFR Part 800; Chapter 27 RCW	Requires the identification of historic properties potentially affected by remedial actions, and ways to avoid, minimize, or mitigate such effects. Historic property is any district, site, building, structure, or object included in or eligible for the National Register of Historic Places, including artifacts, records, and material remains related to such a property.	ARAR if historic properties are affected by remedial activities. No historic properties have been identified at the Site to date, but could potentially be identified during remedial design.
	Archeological and Historic Preservation Act	Alteration of Historic and Archaeological Properties	16 USC 469a-1	Provides for the preservation of historical and archeological data that may be irreparably lost as a result of a federally approved project and mandates only preservation of the data.	ARAR if historical and archeological resources may be irreparably lost by implementation of remedial activities.

Table 4-2 Key Action-Specific ARARs for Remedial Action at the Quendall Terminals Site
Quendall Terminals
Renton, Washington

Remedial Activity	Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
Other Remedial Activities	Native American Graves Protection and Reparation Act	Alteration of American Graves	25 USC 3001-3013; 43 CFR Part 10	Requires federal agencies and museums which have possession of or control over Native American cultural items (including human remains, associated and unassociated funerary items, sacred objects and objects of cultural patrimony) to compile an inventory of such items. Prescribes when such federal agencies and museums must return Native American cultural items. “Museums” are defined as any institution or state or local government agency that receives federal funds and has possession of, or control over, Native American cultural items.	ARAR if Native American cultural items are present in an excavation or dredging area.

Table 4-3 Key Location-Specific ARARs for Remedial Action at the Quendall Terminals Site

Quendall Terminals
Renton, Washington

Act/Authority	Criteria/Issue	Citation	Brief Description	Applicability/Appropriateness
Endangered Species Act	Effects on Endangered Species	16 USC 1531 et seq.; 50 CFR Part 17	Actions authorized, funded, or carried out by federal agencies may not jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their critical habitats, or must take appropriate mitigation steps.	ARAR for remedial actions that may adversely impact endangered or threatened species or critical habitat present at the Site.
Migratory Bird Treaty Act	Effects on Migratory Birds	16 USC 703-712	Regulates taking or killing migratory birds, including feathers and nests.	ARAR for remedial actions that might harm migratory birds or remove or relocate nests.
Fish and Wildlife Conservation Act of 1980, “Nongame Act”	Effects on Fish and Wildlife and Their Habitats	Public Law 96-366, as Amended; 16 U.S.C. 2901-2911	Preserves and promotes conservation of non-game fish and wildlife and their habitats.	ARAR if the remedial action may adversely impact non-game fish and wildlife or their habitats.
Magnuson-Stevens Fishery Conservation and Management Act	Habitat Impacts	16 USC 1855(b), 50 CFR Part 600.920	Requires evaluation of impacts to Essential Fish Habitat (EFH) if activities may adversely affect EFH.	ARAR if the remedial action may adversely affect EFH.
Executive Order for Wetlands Protection	Wetlands Impacts	Executive Order 11990 (1977), 40 CFR Part 6.302(a), 40 CFR Part 6, App. A	Requires measures to avoid adversely impacting wetlands whenever possible, to minimize wetland destruction, and to preserve the value of wetlands.	ARAR for assessing impacts to wetlands, if any, from the remedial action and for developing appropriate compensatory mitigation.
Bald Eagle Protection Act	Effects on Bald Eagles	Chapter 77.12.655 RCW, “Habitat Buffer Zone for Bald Eagles – Rules”; “Bald Eagle Protection Rules” (Chapter 232-12-29 WAC)	Requires buffer zones to be defined around bald eagle nests and roost sites.	ARAR for remedial actions that might be conducted near bald eagle nests or roost sites.

Table 4-9 - DNAPL, Thickness, and Estimated Volumes by Source Area[1]

Quendall Terminals
Renton, Washington

Source Area	Approximate Area in Acres	Cumulative Average/ Maximum DNAPL Thickness in Feet	Average/ Maximum Depth of DNAPL in Feet	Volume of DNAPL-Contaminated Soil and/or Sediment in Cubic Yards	Volume of Soil and/or Sediment to Bottom of DNAPL in Cubic Yards	DNAPL Volume in Gallons	Percentage of Soil and/or Sediment Containing DNAPL[3]	Percentage of DNAPL Logged as Oil-wetted[4]
Former May Creek Channel Area	1.5	2.5 / 8.8 (Max. MC-1)	17 / 34 (Max. BH-30C)	7,100	40,000	88,000	18%	40%
Still House Area	2.2	2.2 / 4 (Max. BH-8)	11 / 14 (Max. QP-7)	8,100	38,000	100,000	21%	27%
North Sump Area[2]	1.6	3.4 / 6 (Max. SP-5)	15 / 18 (Max. SP-7)	9,600	41,000	120,000	23%	3%
Quendall Pond Area Upland	1.6	1.9 / 5.2 (Max. RB-9)	18 / 27 (Max. BH-20C)	4,600	50,000	57,000	9%	58%
Quendall Pond Area Offshore	0.9	1.5 / 5 (Max. VS30)	10 / 16 (Max. VS2)	1,900	17,000	24,000	11%	84%
Rail Road Loading Area	0.2	4.9 / 11 (Max. Q2-D)	22 / 30 (Max. Q2-D)	1,700	7,800	21,000	22%	20%
T-Dock Area (sediment only)	1.7	1.0 / 3.8 (Max. VT-4)	1.5 / 3.8 (Max. VT-4)	2,900	4,400	36,000	66%	0%
Total	**9.7**	**--**	**--**	**36,000**	**200,000**	**445,000**	**--**	**--**

Notes:

[1]Expanded from Table 4.4-4 in the RI Report (Anchor QEA and Aspect, 2012).
[2]North Sump Area locations include: BH-23, HC-2, RB-19, RB-23, SP-5, SP-6, SP-7, SWB-4, and SWB-4a.
[3]Percentage of soil and/or sediment containing DNAPL is calculated as volume of soil/sediment containing DNAPL divided by the volume of soil/sediment to the bottom of DNAPL.
[4]Percentage of DNAPL logged as oil-wetted is calculated as the sum of oil-wetted interval thickness by area divided by the sum of total DNAPL thickness by area.